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The Photons, Contrary to What is Believed, Have a Mass and Density and They Obey the Law of Stefan-boltzmann

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Abstract

In this work we demonstrate that photons, contrary to what is believed, have a mass directly proportional to their frequency. This mass is justified by the combination of 32 constants of physics that I have managed to achieve. The attribution of a mass to the photon is descended from equations, which validates and also demonstrates that it is necessary to define physical concepts such as force and momentum and can justify the increase in mass which is suffered by the particles that are accelerated. However, a photon possesses not only a mass but also has a wavelength that corresponds to length of its radius. If a photon has a mass and radius, it also possesses a density which gives it a spatial dimension. This spatial dimension is a factor that affects the passage of a photon through a narrow and that may explain the behavior of laser beans and future photonic circuits. From what previously reported, we understand that the most energetic photons, having a mass greater than that possessed by the less energetic photons, are denser than the latter and then take up less space. We observe, in the end, that each photon which is formed by energy and matter, also has an energy density. This density corresponds to what Stefan and Boltzmann have attributed to the bodies blacks. This result is extremely important because it shows that the black body radiation is composed of photons that have a spatial dimension.

Keywords

Photonic; Microsystems; Black Body; Laser; Physics; Accelerated Particles

Introduction

What is a photon ?

Einstein , as reported by Silvio Bergia [1] said << Un totale di cinqunt'anni di seria riflessione non mi ha avvicinato alla soluzione del problema: " Che cosa sono i quanti di luce". Naturalmente oggi il primo straccione che passa crede di conoscere la risposta, ma si sbaglia. E non credo di aver tradito sostanzialmente l'originale tedesco << jeder lump>>."

Einstein expressed this conviction 60 years ago and since then have conducted several experiments involving photons directly or indirectly , and we now know much more than what we knew before , but still you can not say that the photon is known in its entirety .

The complementarity principle of Bohr says that a photon is a particle of pure energy that acts as a particle or as a wave. This dual nature, however, can not occur at the same time .

Today this principle is disputed by some experiments [7-13] that seem to show that a photon manifests simultaneously the two behaviors.

Even in my previous work [2], entitled by *"An Investigation on the Double Nature of Photons"* published on Sensor and Microsystems (AISEM 2011 Proceedings) Springer, I questioned the validity of complementarity principle of Bohr.

This is because I have treated the wavelength of de Broglie as if it were produced by a particle that had absorbed a photon that, at the same time, has a mass and wavelength.

I have reached this conclusion because the formula that I realized:

mass of photon = (l_P^2 c/G) ν

were is that:

l_P = Planck length = 4,050 x 10^{-35} m
c = speed of light in vacuum = 2,99792 x 10^8 m/s
G = Newtonian constant of gravitation = 6,673 x 10^{-11} (m^3 kg^{-1} s^{-2})
ν = frequency

shows that there is a deep connection between the mass of photon and its frequency.

From reported above, we realize that my vision of the photon is different from the traditional.

Physics, in fact, believes that photons are to be regarded as particles immaterial, or waves.

Following further studies, I came to the conclusion that a photon has a mass and also a spatial dimension.

According to my vision, the photon is therefore a corpuscle in need of a mass to be able to use the energy which it possesses.

A gamma photon and an infrared photon possess a different energy, but, since they travel at the same speed, it is not clear why they should have a different energy. Their different energy can be justified by the possession of a different mass that, to move about, requires a different energy. It must be said, also, that a photon, massless, does not agree with many of the concepts of physics.

We know very well that a photon has a momentum, but when we want to define this greatness you can not use the classical equation q = mv because the physics does not give the photon a mass.

In lack of a mass, photonics does not allow using the classical equation used to define the rotation (spin) of a particle.

Furthermore, the lack of a mass and an acceleration does not allow to define the force that a photon exerts on a wall.

In reality, the photon has a strength, because it has both an acceleration and a mass. These, in fact, determine a pressure that can be measured.

Density of Mass of Photon

Suppose that a photon is equipped with a mass *m* and let us suppose that there is a spherical particle with a radius *R* corresponds to the wavelength.

In this condition, it verifies the equation:

$$m \lambda c = h = \text{angular momentum} \quad (1)$$

This equation tells us that this hypothetical particle rotates on itself at the speed of light.

From equation (1) we get:

$$m \lambda = h/c = \text{constant}$$

This means that when the mass is large, the wavelength must be small and, therefore, the radius must also be small.

Therefore, a photon with large mass is more dense than a photon with a small mass.

Now we calculate the density of mass of the photon.

We make the relationship between the photon energy E = hν and volume photonic V = (4/3) π λ^3

We get:

$$d(\text{energy}) = \frac{h\,\nu}{(4/3)\pi\,\lambda^3} = \frac{3\,h\,c}{4\,\pi\,b^4}\,T^4 = \frac{3\,h}{4\,\pi\,c^3}\,\nu^4$$

were is that: $T = \frac{b}{\lambda} = \left(\frac{b}{c}\right)\nu$;

$$d(\text{matter}) = \frac{3\,h}{4\,c\,\pi\,b^4}\,T^4 = \frac{3\,h}{4\,\pi\,c^5}\,\nu^4$$

Now we observe that:

$$d(\text{energy}) = \frac{3\,h\,c}{4\,\pi\,b^4}T^4 = \frac{3 \times 6{,}626 \times 10^{-27}(\text{erg} \times \text{s}) \times 2{,}9979 \times 10^{10}(\text{cm/s})}{4 \times 3{,}14 \times [0{,}289\ (\text{cm} \times \text{K})]^4} = 6{,}8 \times 10^{-15}\ T^4\ (\text{erg/cm}^3)$$

This Equation corresponds to Stefan-Boltzmann.

The Mass o Photon

We have seen that, for a photon without a mass, it is not possible to agree with many physics formulas.

I have defined the mass of a photon through the formula:

m (photon) = $k_A\ \nu$

The constant k_A displayed in this equation was justified by me using eight physical constants such as Planck's constant (quantum mechanics), the gravitational constant (gravitation of Newton and Einstein) and speed light (special relativity).

$$k_A = \frac{l_P\,m_P^2\,G^{1/2}\,b^2}{t_P^2\,T_P^2\,h^{1/2}\,c^{7/2}} = \frac{4{,}05 \times 10^{-33} \times (5{,}46 \times 10^{-5})^2 \times (6{,}67 \times 10^{-8})^{0{,}5} \times (0{,}289)^2}{(1{,}35 \times 10^{-43}) \times (7{,}168 \times 10^{31})^2 \times (6{,}626 \times 10^{-27})^{0{,}5} \times (2{,}9979 \times 10^{10})^{3{,}5}} =$$
$$= 7{,}372 \times 10^{-48}\ (g \times s)$$

And it is interesting to note that in this equation there are also four parameters related to the Planck time that is in relation with the origin of the universe.

The mass of a photon can also be justified by a constant k_A, which derives from a combination of 32 physical constants. These constants represent almost all physics we know, and, therefore, this justifies in an excellent way the mass of the photon.

$$k_A = \frac{b^3 c\,k_B^2\,q_P^2\,m_e^4\,e^4\,\alpha_S\,(m_{pr}/m_e)^3\,Z_0\,G_0\,N_A\,F\,t_P}{512\,\pi\,m_{pr}^2\,G^3\,d^2\,\mu_0\,T_P^2\,h^2\,m_P^3\,(d_P/d)\,V_m\,(0{,}44 \times 10^{-39})\,K_C\,l_P^4\,R\,E_P\,R_{inf}\,\alpha^2\,\mu_B\,\varepsilon_0^5} = 7{,}372 \times 10^{-48}(g \times s)$$

The constants in the equation are as follow:

b = Wien constant = 2,897 x 10^{-3} (m °K)
c = speed of light in vacuum = 2,99792 x 10^8 m/s
k_B = Boltzmann constant = 1,380 x 10^{-23} (J °K^{-1})
q_P = Planck charge = 1,875 x 10^{-18} C
m_e = electron mass = 9,109 x 10^{-31} kg
e = elementary charge = 1,602 x 10^{-19} C
α_s =hard coupling constant = 1
(m_{pr}/m_e) = proton mass/electron mass = 1836,152
Z_0 = characteristic impedance of vacuum = 376,730 Ω
G_0 = conductance quantum = 7,748 x 10^{-5} (s Ω^{-1})
N_A = Avogadro constant = 6,022 x 10^{23} (mol^{-1})
F = Faraday constant = 96485,3365 (c mol^{-1})
t_P = Planck time = 1,350 x 10^{-43} s
m_{pr} = proton mass =1,67252 x 10^{-27} kg
G = Newtonian constant of gravitation = 6,673 x 10^{-11} ($m^3\ kg^{-1}\ s^{-2}$)
d = nuclear density = 2,918 x 10^{17} (kg/m^3)

μ_0 = magnetic constant = 12,566 x 10^{-7} (N A^{-2})
T_P = Planck temperature = 7,168 x 10^{31} °K
h = Planck constant = 6,626 x 10^{-34} (J x s)
m_P = Planck mass = 5,455 x 10^{-8} kg
(d_P/d) = Planck density/nuclear density = 2,814 x 10^{78}
V_m = molar volume of ideal gas (a T = 273,15 °K e P = 100 kPa) = 22,710 x 10^{-3} (m^3 mol^{-1})
(0,44 x 10^{-39}) = electromagnetic coupling constant
K_C = Coulomb constant = 8,992 x 10^9 (N m^2/C^2)
l_P = Planck length = 4,050 x 10^{-35} m
R = ideal gas constant = 8,313 J/(°K mol)
E_P= Planck mass energy = m_P x c^2 = 4,902 x 10^9 J
$R_{inf.}$ = Rydberg constant = 1,097 x 10^7 m^{-1}
α = fine structure constant = 7,297 x 10^{-3}
μ_0 = Bohr magneton = 927,400 x 10^{-26} (JT^{-1})
ε_0 = electric constant = 8,854 x 10^{-12} (F m^{-1})
π = 3,14

Photon Density Justified by Its Spin

If we insert a photon in a confined space , it expresses its energy by turning on its own mass- . The more dense it is the greater the energy of the photon . This movement of spin creates a standing wave characterized by a wavelength and a frequency .

The photon confined rotates at the speed of light and has a mass ($m = k_A \nu$) with a radius equal to its wavelength and obeys the equation :

$(k_A \nu)\ \lambda\ c$ = h = Planck constant = angular momentum; where is that: λ = Radius of a photon

If we substitute in this equation , for the Wien's law , the frequency ν with (c/b)T and if we substitute the wavelength λ with R , we obtain:

$$R = \frac{h\ b}{k_A\ c^2\ T} = \text{Radius of a photon}$$

The knowledge of the radius allows us to obtain the volume of the photon:

$$V = \frac{4\ \pi\ h^3 b^3}{3\ k_A^3\ c^6\ T^3} = \text{volume of a photon}$$

According to the ratio between the mass of a photon with its volume, we get:

$$d = \frac{3\ k_A^4\ \nu\ c^6}{4\ \pi\ h^3 b^3}\ T^3 = \text{material density of a photon}$$

Now replace the frequency ν of the above equation with (c/b)T and we get:

$$d = \frac{3\ k_A^4\ c^7}{4\ \pi\ h^3 b^4}\ T^4 = 7{,}565 \times 10^{-36}\ T^4 = \text{material density of a photon as a function of } T^4$$

This equation demonstrates that each photon is a corpuscle dense material, whose density is directly proportional to the fourth power of its temperature.

This photon density may also be expressed in function of the frequency of the photon. By the law of Wien $T^4 = (b^4/c^4)\nu^4$, it is obtained that:

$$d = \frac{3\ k_A^4\ c^3}{4\ \pi\ h^3}\ \nu^4 = 65{,}338 \times 10^{-81}\ \nu^4 = \text{material density of a photon as a function of } \nu^4$$

It can be shown that photons are particles, with density material, that obey the equations written above?

This can do the equation of Stefan-Boltzmann.

This equation expresses the energy density of the photons which wrap a black body. Its analytical form is:

$$\mathrm{d(energia)} = \frac{8\,\pi^5 k^4}{15\,h^3 c^3} T^4 = 7{,}56464 \times 10^{-15}\ T^4 (\mathrm{erg/cm^3})$$

In addition, this equation is a function of the fourth power of the absolute temperature and this portends something very important.

We rewrite the equation displayed at the end of pag. 4 :

$$\mathrm{d} = \frac{3\,k_A^4\,c^7}{4\,\pi\,h^3\,b^4} T^4 = 7{,}565 \times 10^{-36}\ T^4 = \text{material density of a photon as a function of } T^4$$

and multiply both its members for c^2 .

We get:

$$\mathrm{d} = \frac{3\,k_A^4\,c^9}{4\,\pi\,h^3\,b^4}\ T^4 = \text{ energetic density of photon}$$

This equation gives us:

$$\mathrm{d} = \frac{3 \times (7{,}372 \times 10^{-48})^4 \times (2{,}9979 \times 10^{10})^9}{4 \times 3{,}14 \times (6{,}626 \times 10^{-27})^3 \times (0{,}289)^4} T^4 = 6{,}798 \times 10^{-15}\ T^4 (\mathrm{erg/cm^3})$$

This proves beyond doubt that the energy density of a photon corresponds to energy density that Stefan and Boltzmann have attributed to a black body. This also shows that the photons of a black body are arranged next to each other and form a compact aggregate of massive photons that move at the speed of light.

The energy density of a photon, obtained by the equations first examined, corresponds with very good approximation , to the energy density of a black body that follows the law of Stefan-Boltzmann as below [3]:

$$u = \frac{8\,\pi^5\,(k\,T)^4}{15\,(h\,c)^3} = 7{,}56464 \times 10^{15}\ T^4\ (\mathrm{erg/cm^3})$$

If the energy density of a black body is approximately equal to that of the photons that populate the black body, this means that the black body is surrounded by photons spatially extended .

Einstein himself believed that light was composed of "quanta" spatially extended. He, in his article intitled *"On The Electrodynamics of Moving Bodies"* , he said, as reported by Silvio Bergia [1], that light was composed of <<quanti di energia localizzati nello spazio>>. In that same article, which he considered very revolutionary, as is apparent from the letter sent to his friend Habicht in May 1905, it is clear that Einstein had initially a dualistic view of the radiation. He, in fact, thought that the light quanta behaved at the same time both as waves and as particles. I share this thought of Einstein.

But a Particle with Mass Can Move at the Speed of Light?

Some argue thate a photon with mass can not move at the speed of light, because that it is prohibited by Einstein's special theory of relativity.

This observation is correct if it is used for those particles that move without the help of the energy from the outside.

The particles, such as electrons and protons, which, on the contrary of the photons, they need to receive energy, in order to move, they can not move at the speed of light.

For these particles equation applies:

$$(k_A\,\nu)\,c = \left[m_{(\mathrm{part})} + (k_A\,\nu)\right] v$$

This equation shows that the photon, which provides energy to the particle to make it move, it-becomes even heavier because it also acquires the mass of the particle.

The photon, weighed down by presence of the particle, continue to use its momentum as it did before, but this is no longer sufficient to maintain the speed of light.

Therefore, its speed is lower.

The following demonstration shows that the particle, that is considered as the most massive of physics- , which is the mass of Planck, can rotate at the speed of light.

This happens because the rotational movement is a movement that does not require external energy.

If we multiply together the two notes expressions, we can obtain as follows:

$$m_p = \left(\frac{c\,h}{G}\right)^{1/2} ; \qquad l_p = \left(\frac{G\,h}{c^3}\right)^{1/2} ; \qquad m_p\, l_p\, c = h$$

This is the equation of the angular momentum of a Planck mass. This mass has a radius equal to its wavelength and rotates on itself at the speed of light while possessing a mass.

Proton and Electron Radius

We know very well that even protons and electrons possess a movement of spin that is worth half of Planck constant. This movement is a movement that does not take energy from the outside and, therefore, does not increase the mass of the particles. Moreover, it happens at the speed of light without violating the law of relativity.

Its angular momentum is:

$$m_{Pr}\ R\ c = (1/2)\ h$$

From this equation, the following is obtained:

$$R = h\ /(2\ m_{Pr}\ c) = (0{,}5 \times 6{,}626 \times 10^{-27})/(1{,}67252 \times 10^{-24} \times 2{,}9979 \times 10^{10}) = 6{,}607 \times 10^{-14}\ \text{cm}$$

Aldo Antognini [4], which is part of the Max Planck Institute for Quantum Optics in Garching and the Institute for Particle Physics at the ETH in Zurich, and his colleagues, measured the proton. This measurement was smaller than that which has been obtained so far by other researchers. The radius of the proton that Antognini and colleagues were able to measure possesses a value of $8{,}4087 \times 10^{-14}$ cm. To perform this measurement, Antognini and Colleagues used a hydrogen atom specially in which the electron has been replaced by a muon, which is a type of electron about two hundred time heavier.

This substitution allows the proton to get very close to the muon, but, this does not mean that the two particles can stick together. This, to me, means that the measure of the hydrogen atom, with the muon, is different from the measurement of the single proton. The measurement of the proton, which I made using its angular momentum, may be closer to reality than that made with the muon.

In physics there are those who regard the electron as if it were a cloud and those who treat it as point without size. The angular momentum of an electron clearly indicates that, if the electron is without dimension, it must rotate at speed infinitely greater than that of light.

Sean Carroll [5], in his book *"La Particella alla Fine dell'Universo "*, Le Scienze (ed ital. di Scientific American) and Codice Edizioni, refers to the page of 121 << Alte masse corrispondono a basse lunghezze d'onda, il che significa che una particella occupa meno spazio. Questo è il motivo per cui sono gli elettroni, non i protoni o i neutroni, a definire le dimensioni di un atomo; essendo le particelle più leggere coinvolte, hanno la lunghezza d'onda maggiore e perciò occupano più spazio.>>

A Laser Beam Is Formed by a Compact Aggregate of Photons and Obeys the Law of Stefan-Boltzmann?

Now we observe that the Stefan-Boltzmann equation can be expressed as shown below:

E = spectral density of the unit of surface (radiation of cavity) $= \sigma\ T^4 = 5{,}68 \times 10^{-5}\ T^4$ [erg/(s cm^2)]

This equation take into account the energy emitted from a unit area of a black body in the time of 1 second. In the case of a black body, the energy emitted by it refers to a spectrum of energy that follows the Planck distribution law. In the case of a laser, however, the emitted photons all have the frequency.

So far- , we have verified that a black body emits photons that have their own energy density and material density and produce an energy density such as that provided by the Stefan-Boltzmann. But we are not able to say that the same thing happens with a laser beam . To be able to provide a response to that effect, is necessary to know the exact number of photons in a laser beam. I do not know this number but experts might know him. It is to be noted, however, that if the photons of a laser beam form a compact aggregate that travels at the speed of light, their energy density certainly corresponds to that of Stefan-Boltzmann.

There is a possibility to verify whether a laser follows the Stefan-Boltzmann. California is the most powerful laser in the world and is an x-ray laser called Linac Coherent Ligth Source (LCLS). This laser consists of a very thin beam that realizes a temperature of two million degrees , and that, in time of 1 second, produces a thin long cylinder 3×10^{10} cm^3 . It is necessary to determine whether this cylinder contains within it a number of photons corresponding to that provided by the Stefan- Boltzmann.

A Photon Can Pass Through a Tunnel Only If Its Dimensions Allow Its Passage

A photon is a particle composed of matter and energy and has a spatial dimension. It can pass through a tunnel only if it has an appropriate size. Instead, a photon without mass can pass through any tunnel. I attributed to each photon a volume that is filled by a mass. The experiment that I illustrate here below produces a pressure such as that provided by physics. In physics the pressure is calculated from the ratio of the energy and volume.

We introduce a gamma photon in an ideal cylinder of 30 cm in length, with a base of 2.822×10^{-19} cm^2 and a volume of 8.466×10^{-18} cm^3 .

The physics informs us that this photon, as confined, produces a pressure of 78250 bar which, for a particle, constitutes a pressure infinitely large.

In fact, this pressure can be justified with Newton's laws. The photon (takes the time of a nanosecond to traverse around the cylinder) passes through a portion of the cylinder 30 cm long in the time of one nanosecond. At the end of this path this particle starts to turn on itself at the speed of light and therefore retains all its energy.

The force with which the photon hits the wall is calculated using the equation:

$$f = m\,(c/t) = \text{mass} \times \text{acceleration}$$

The relationship between this force and the surface of the wall calculates the pressure. This pressure (corresponds to that of the physical) is equal to that used from physics. It should be noted that the cylinder used for this experiment has a radius equal to the wavelength of the photon. A cylinder with a radius (smaller than that of photon) less than that of the photon is not suitable for this experiment. If the cylinder considered above, instead of being (of) 30 cm in length, has a length of 3×10^{10} cm , the photon that realizes this trip reaches its destination by impressing on the wall a force of 2.210×10^{-17} dynes.This force is significantly less than the force that the photon produces when it runs only a path of 30 cm- . This result is very interesting because it shows that the strength of a photon decreases with the passage of time.

We conclude this section by saying that in the cylinder it can find accommodation (only) gamma photons, (such as) as we have seen before , and even (more) the most energetic photons. In this cylinder, however, it can not be placed photons that have low energies because their size does not allow it.

Summary of the Proposed Equations

photon mass = $k_A \nu = 7{,}372 \times 10^{-48} \nu$ (g)
photon mass = $k_A\,(c/b)\,T = 7{,}647 \times 10^{-37}\,T$ (g)
photon volume = $0{,}101 \times T^3$ (cm^3)
photon volume = $1{,}127 \times 10^{32} \times \nu^{-3}$ (cm^3)
photon density = $7{,}565 \times 10^{-36}\,T^4$ (g/cm^3)
photon density = $6{,}533 \times 10^{-80}\,\nu^4$ (g/cm^3)

The next table shows the properties of three types of photons such as gamma photons, IR-Visible photons and microwave.

Frequency = 10^{20} hertz Temperature = 9,640 x 10^{8} K	Frequency = 3 x 10^{14} hertz Temperature = 2892 K	Frequency = 2,826 x 10^{11} h. Temperature = 2,725 K
Mass = 7,372 x 10^{-28} g	Mass = 2,211 x 10^{-33} g	Mass = 2,083 x 10^{-36} g
Volume = 1,127 x 10^{-28} cm^3	Volume = 4,175 x 10^{-12} cm^3	Volume = 4,991 x 10^{-3} cm^3
Density = 6,533 g/cm^3	Density = 5,291 x 10^{-22} g/cm^3	Density = 4,171 x 10^{-34} g/cm^3

Researchers who have created a super photon, using a Bose-Einstein condensate, have faced a problem that initially seemed insoluble. This happened because the photons cooled strongly tend to disappear. This is fully verified by my equations.

Conclusions

In this paper some original equations were presented by the author. These equations show that the photons, contrary to what is believed, not only have a mass directly proportional to their frequency, but also possess a density which is directly proportional to its mass. It is clear, therefore, that the spatial dimension, that a photon has, influences its movements. In this work, we have also seen that if the photons have a mass, it is possible to use, for them, physics formulas, as the strength of a photon, which, without the mass of the photon, could not be calculated. Defining a force for a photon is of fundamental importance to be able to use the Newton dynamics and also to be able to understand how this force undergoes changes when varying the length of the path. Finally, we have also seen that spatially extended photons are able to agree very well with the law of black body that was formulated by Stefan and Boltzmann.

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Pasquale Acquaro was born in Vibo Valentia (Italy). He gratuated in chemistry (physical chemistry) at the University of Padua (Italy) in 1972. He won the competition for the teaching of matematics. He was a professor of chemistry in technical schools of Italy and took part in some competitions of the Ministero dei Beni Culturali e Ambientali of Italy and has received very positive reviews by academics of the Accademia dei Lincei as Nicola Cabibbo, Piero Caldirola, Luigi Radicati, Lamberto Malatesta etc... He was a member, for seventeen years, of the Società Chimica Italiana (SCI) and has presented numerous communications in national congresses of the SCI. He was invited to partiecipate, with its oral communication entitled *"Photons Present a Double Nature: They Are Waves and Material Particles at the Same Time and Follow a Physical Law"*, into a national conference convened by Italian National Agency for New Technologies Energy and the Environment of Rome (ENEA) and by Associazione Italiana Sensori e Microsistemi (AISEM). He is the author of a book on cosmology entitled "Un microscopico buco nero all'origine dell'universo" edizioni Monteleone, and he is the author of an equation of state for gases and liquids highly compressed, that magazine "La Chimica e L'Industria" of Milan (Italy) judged this equation the best among those proposed so far and that the magazine Didattica delle Scienze of Brescia (Italy) has published his pretentious articles under the title of "Da van der Waals ad Acquaro". In January 2012, the AISEM has published a book containing a selection of the papers presented at the 16th conference on sensors and microsystems and between them he has entered the author's work entitled "An investigation on the double nature of photons". In this work there is also an equation of the author that demonstrates that photons have a mass directly proportional to their frequency. In the same work the author proposed, anticipating the conclusions obtained by several international research groups, that the Principle of Complementarity of Bohr can be circumvented. Other fields interesting the author are termodynamics and particle acceleration. He has critically reviewed the theory of Carnot on heat engines and the concept of internal energy and has revised critically the wavelength of de Broglie. Another field of interest for the author are the cosmology. He is currently preparing a book about the Universe in which it also shows how it originated from the big bang and what are the mechanisms that regulate the expansion of the universe for a time that precedes the Planck time and up to the present day and beyond. This model produces temperatures, volumes and energies in perfect agreement with those of cosmology.